

# Resolving the Earthquake Source Scaling Problem: Part 1: Regional Spectra



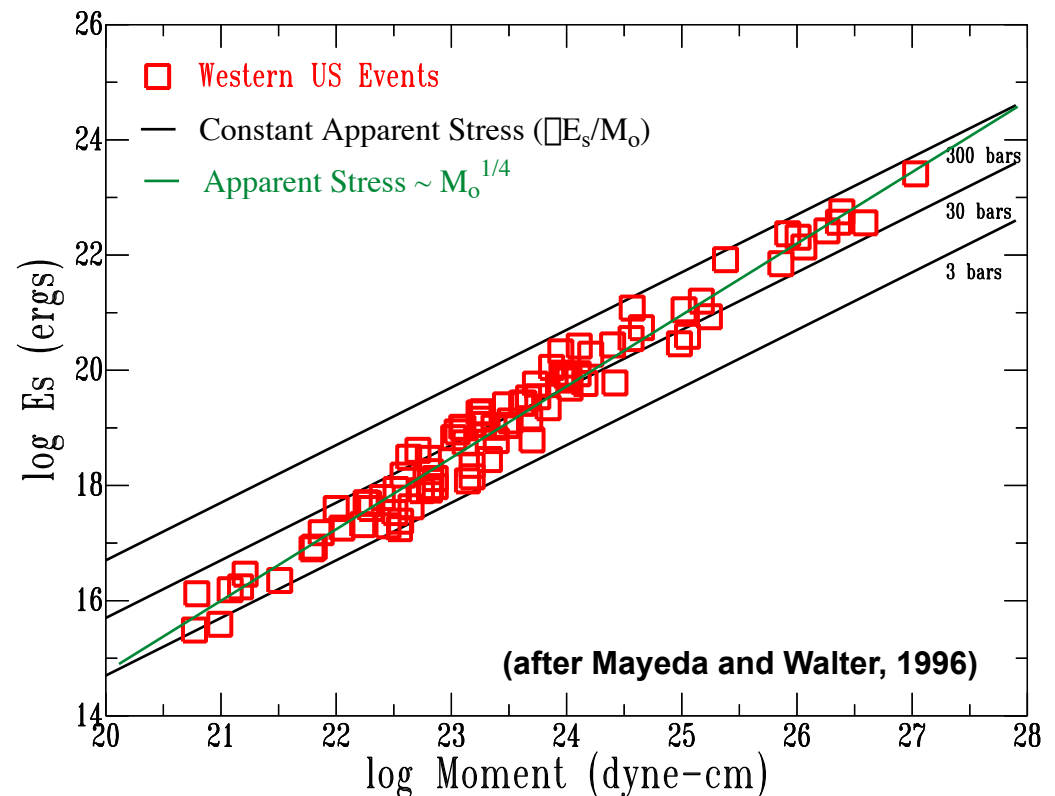
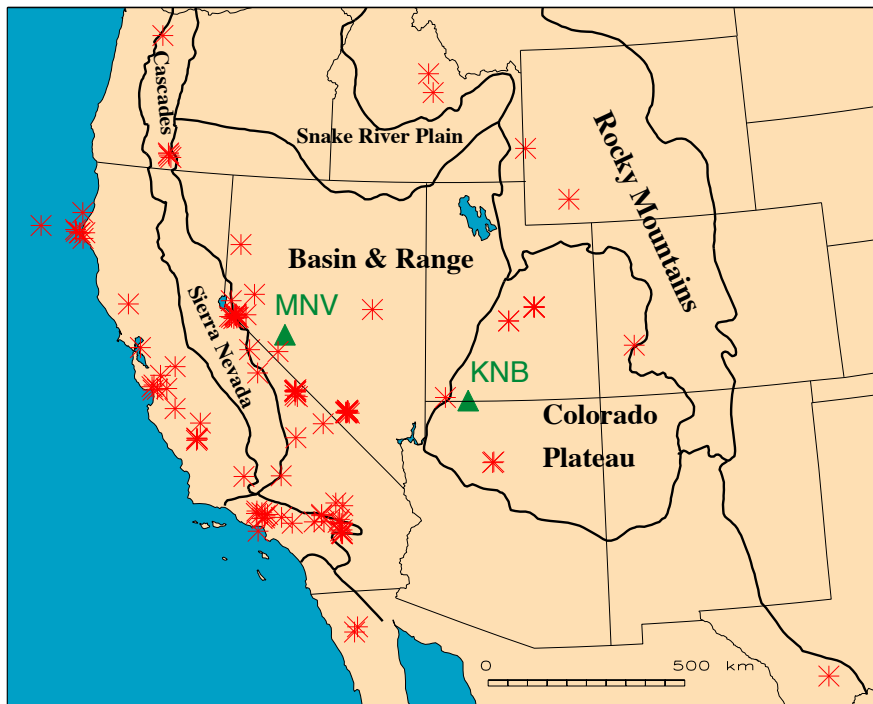
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Lab-Wide LDRD Project  
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Earthquake Energy Scaling Workshop  
Wente Vineyards, Livermore CA

# Recently we won LW LDRD funding to revise and update our 1996 study of earthquake energy scaling



1996 study used 117 western U.S. earthquakes



We will greatly improve on earlier work by:

- 1) increasing the number of events by a factor of 5 (especially  $M < 4$  and  $M > 6$ )
- 2) comparing results to a second independent technique (MDAC)
- 3) including accurate uncertainty measures for energy and moment
- 4) determining slope and variance for two regions (Western U.S. and Middle East)

# MDAC2 - Magnitude and Distance Amplitude Correction is a earthquake seismic spectral fitting technique



For nuclear test monitoring purposes Walter and Taylor (2002) developed a model to predict earthquake spectra. The instrument-corrected regional amplitude of a particular phase (e.g. Pn, Pg, Sn, Lg, Coda-envelope) at a particular station:

$$A(\omega, R) = S(\omega) G(R) P(\omega) B(\omega, R)$$

where  $\omega$  is the angular frequency and  $R$  is the distance and:

$S(\omega)$  is the source spectrum (modified Brune 1970 type with variable apparent stress)

$G(R)$  is the geometrical spreading (Street et al 1975 type)

$P(\omega)$  is the site effect

$B(\omega, R)$  is the apparent attenuation (frequency dependent  $Q$ )

resulting in:

$$\log A_m(\omega, R) = \log(FM_o) + \log \left[ 1 + \frac{R^2}{R_c^2} \right] + \log G(R) + P(f) + \frac{R \log e}{Q_c} \left[ \frac{1}{2} \right] \log(e)$$

$$\omega_{cs} = \frac{K \omega_a}{M_o}^{1/3} \quad \text{where} \quad K = \frac{16}{\frac{R_s^2 \omega_c^3}{\omega_s^5} + \frac{R_s^2}{\omega_s^5}}$$

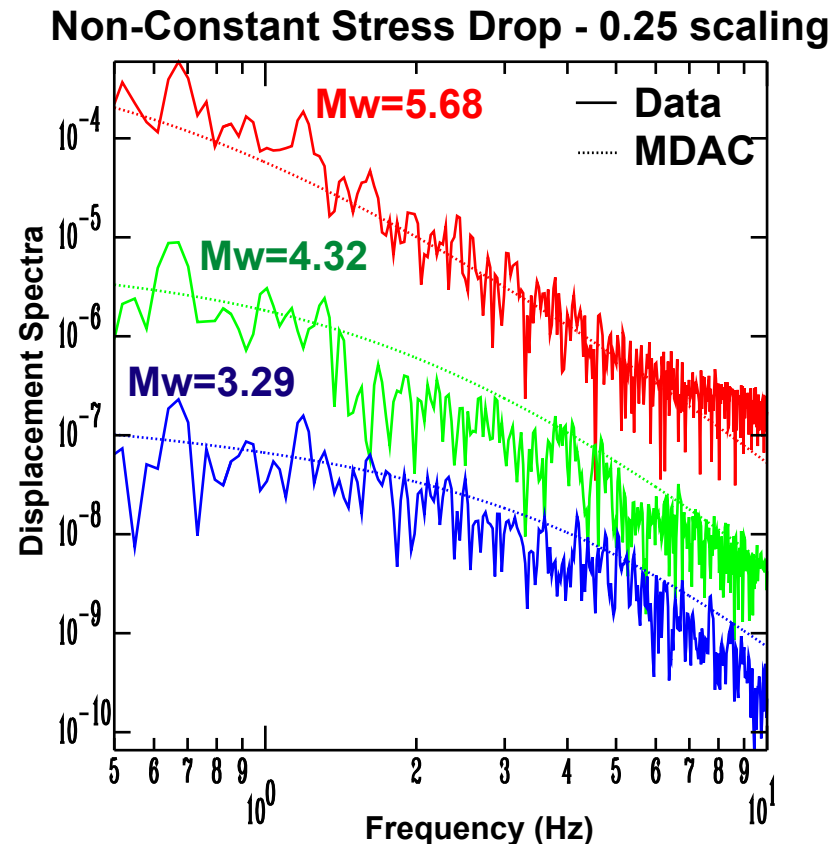
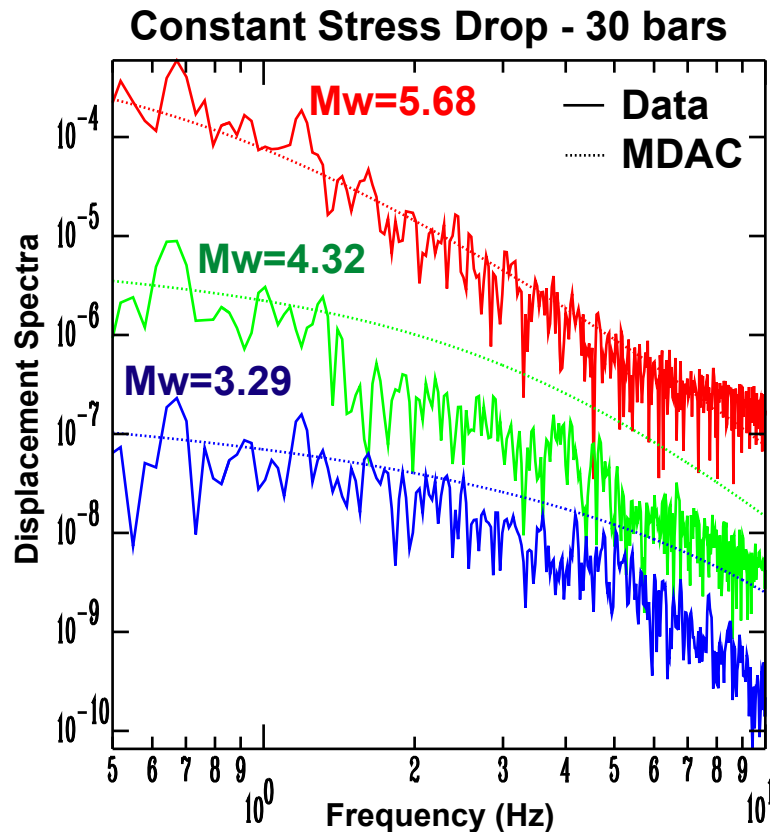
Where the corner frequency  
is in terms of apparent stress

(Walter and Taylor, UCRL-ID-146882, 2002)

# We evaluate whether constant or variable apparent stress better fits individual earthquake sequences with MDAC2



Example: MDAC Lg spectral fits to NTS 1992 Little Skull Mountain earthquakes



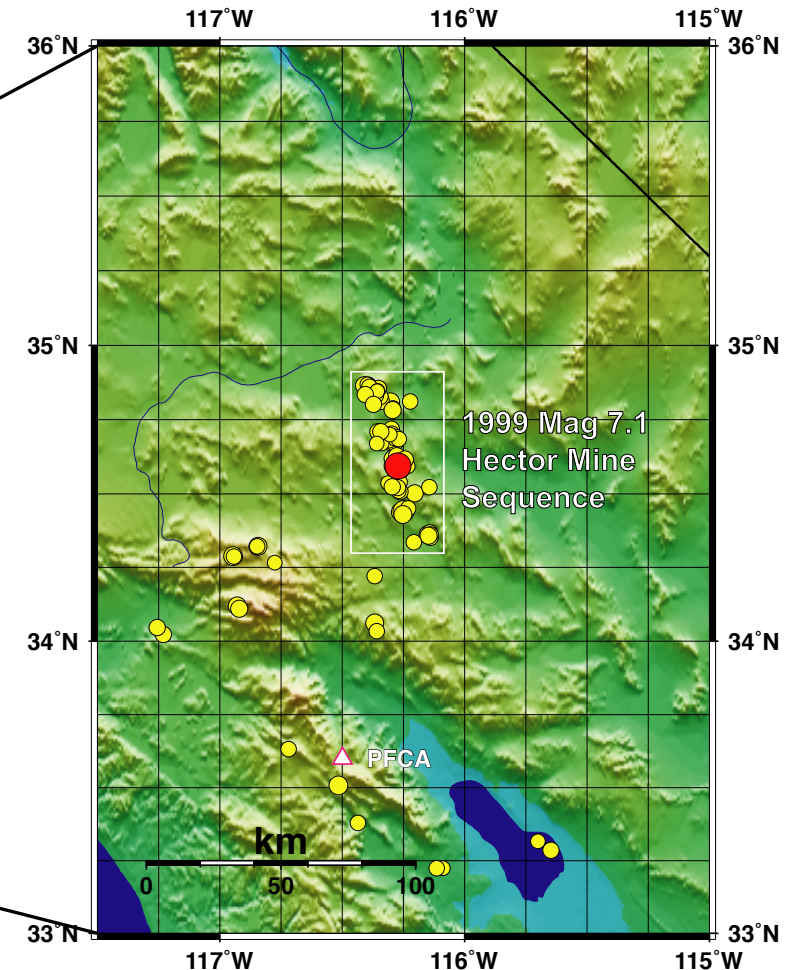
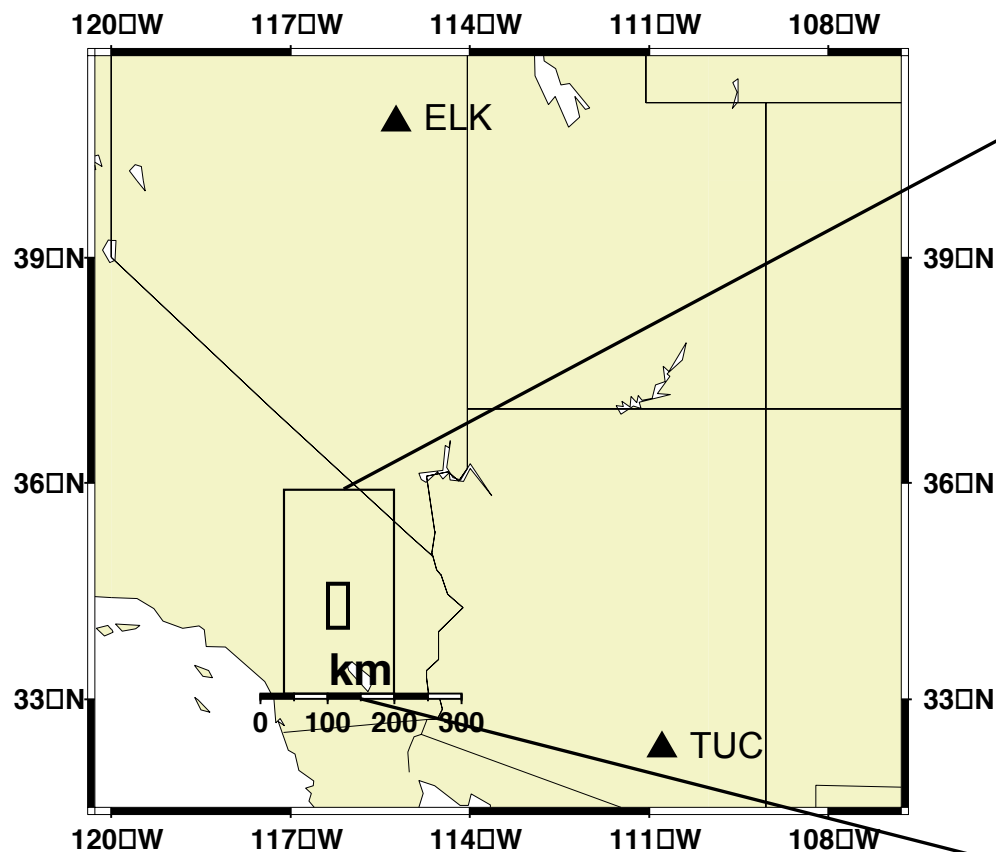
By examining earthquake sequences at the same station, we have common path and site effects, and the observed differences can be attributed to the source.



# We evaluate energy scaling for large earthquake sequences like Hector Mine for constant station and path



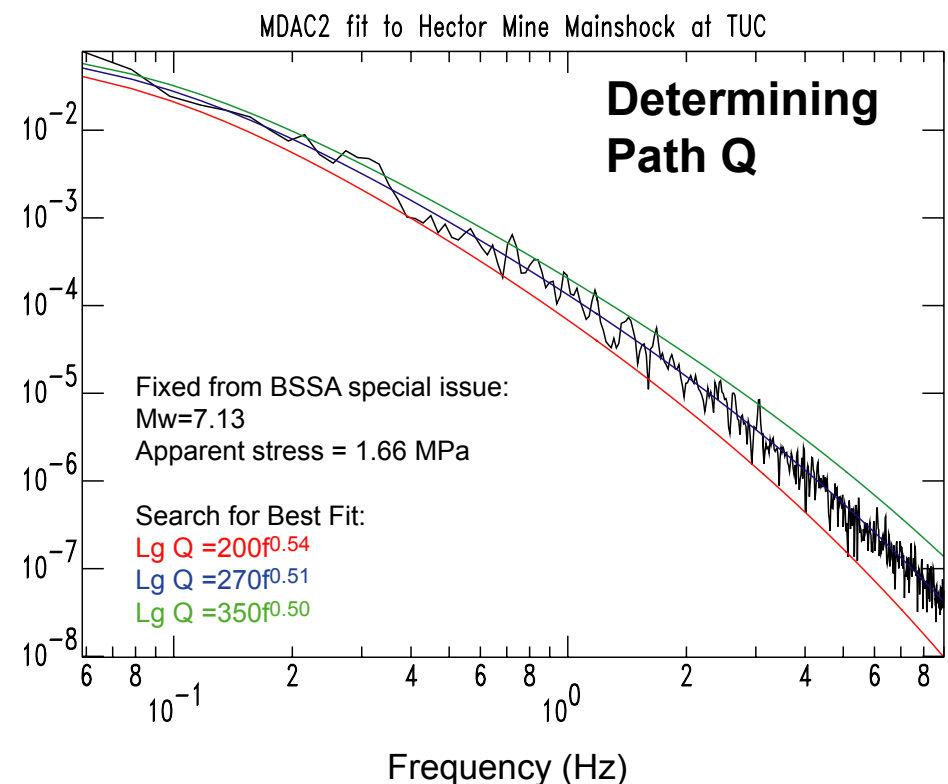
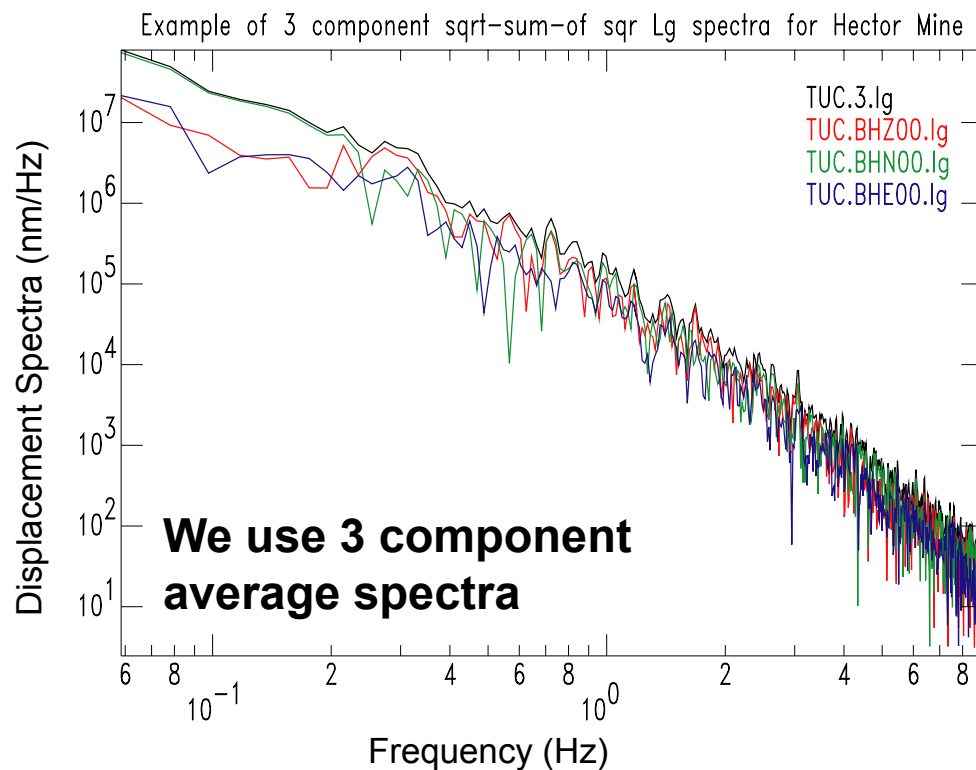
Magnitude 4+ Earthquakes from 1998-2002



# We use independent mainshock moment and apparent stress to determine path correction

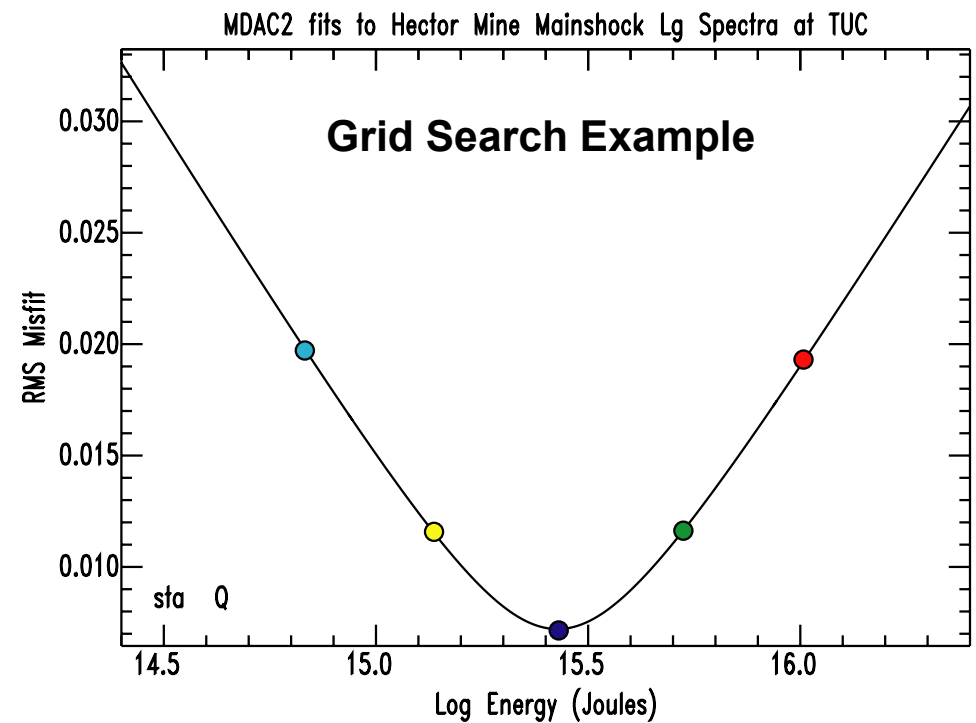
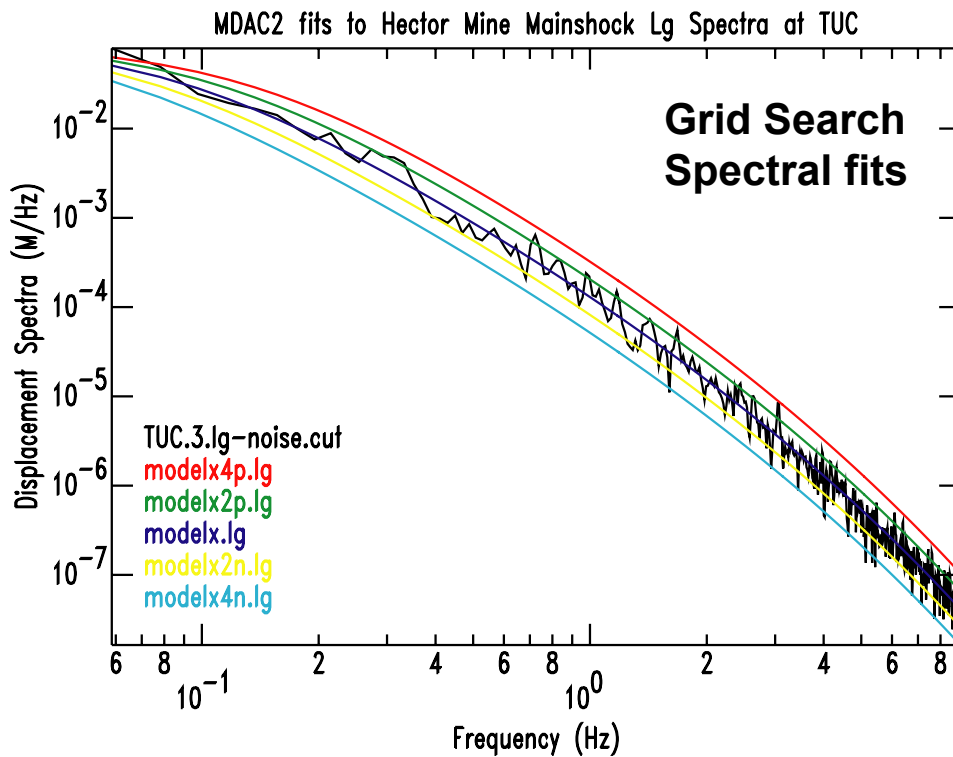


We use 3-component spectra and grid search for best fitting frequency-dependent Q for each phase at each station

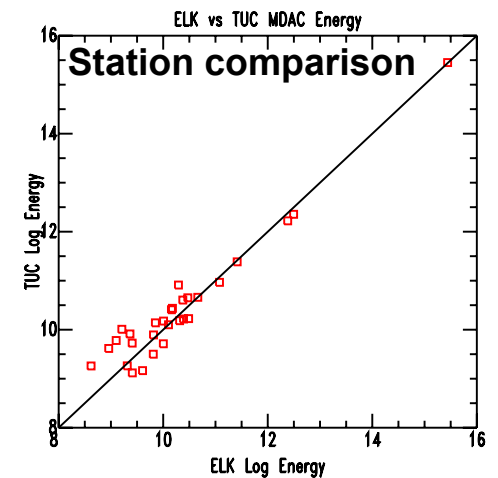
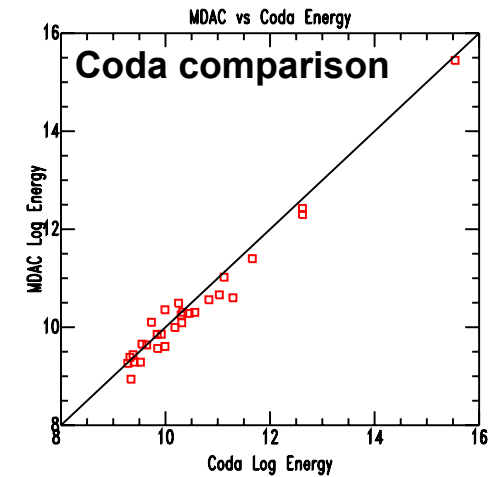
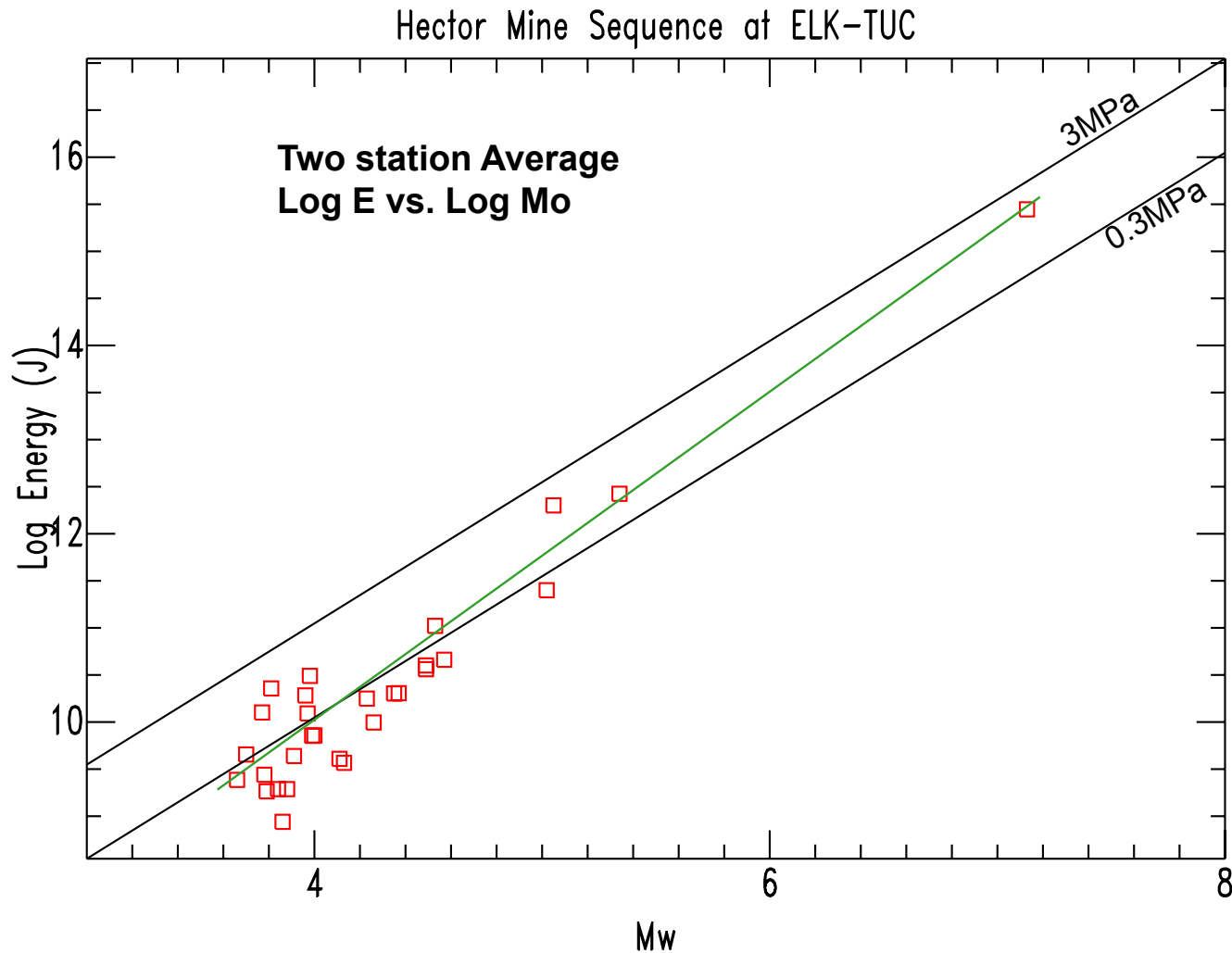


All Hector Mine events are then evaluated using this correction

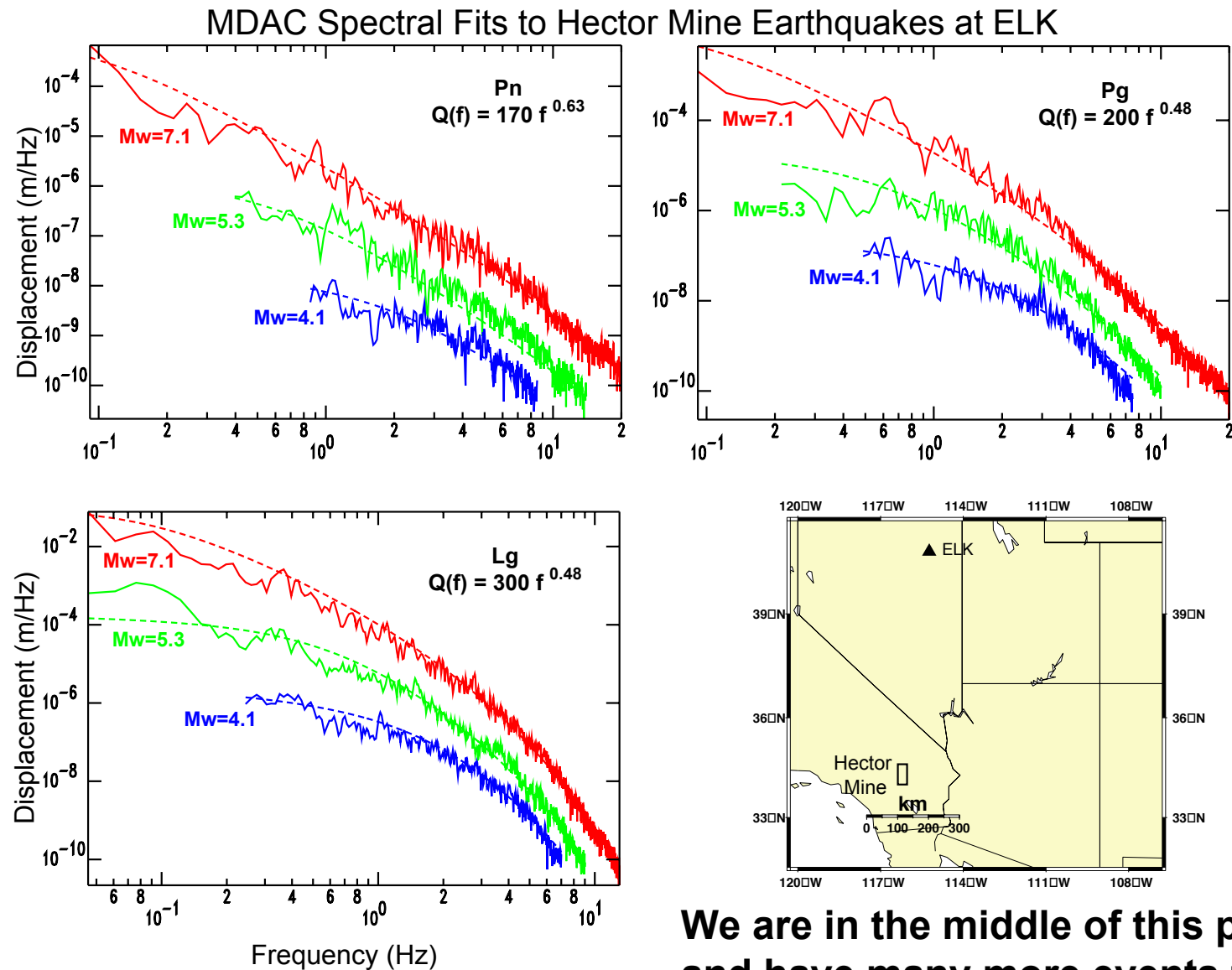
For each event we grid search for the best fitting energy value and uncertainty using the calibrated path



# Spectral energies show apparent stress scaling and energy values are consistent with coda estimates



**We can do the same analysis on Pn and Pg spectra**  
**So far all phases and coda show similar scaling**



**We are in the middle of this project**  
**and have many more events to analyze**